Marine Research

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Marine Research
1958 No. 9

The Occurrence of *Nicothoë astaci* Audouin and Milne Edwards on Scottish Lobsters

By JAMES MASON, B.Sc., Ph.D.

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The Occurrence of *Nicothoë astaci* Audouin and Milne Edwards on Scottish Lobsters.

INTRODUCTION

Nicothoë astaci is a choniostomatid copepod (Gurney, 1929) parasitic on the gills of the lobster, *narus vulgaris* Milne Edwards. Its existence on lobster gills has long been known to fishermen, though y recently has it come to be regarded as a possible cause of lobster mortality, especially in transit and ing storage in ponds and tanks.

The lobster is of considerable commercial importance in Scotland, where, in 1957, landings totalled 59,190, valued at £266,431. A considerable proportion of the catch is exported to the continent of ope, especially to Holland. In June 1955, there was a high mortality among the lobsters stored in ds at Yerseke, Holland. It was found that the lobsters, some of which had been imported from tland, were heavily infested with *Nicothoë*. In view of the lobster's importance, a programme of work instituted on the biology of the parasite and its effect on the host. The work on the biology of *Nicothoë* been reported elsewhere (Mason, 1959), and is summarised briefly here.

The only individuals so far definitely recognised have been females. Ripe eggs from the gonads into the egg-sacs; changes in the gonads and egg-sacs then take place concurrently, so that, when gonad is again full of ripe eggs, the egg-sacs either contain active cyclopid larvae or have just released n. The cycle is then repeated. After the release into the sea of the cyclopid larvae, which are 0·27–0·29 long, there is a gap in our knowledge of the life cycle, the next stage known being the much larger 6–0·99 mm long) last-stage copepodid on the gills of the lobster. The latter has the full adult plement of limbs, but lacks the large lateral wings. From it can be traced a series of changes, with appearance of wings and the development of gonads, through juveniles (which have never spawned) dults with egg-sacs. All attempts to bridge the gap have failed.

No male individuals were found, though all last-stage copepodids examined had spermathecae aining sperm, so that they must have been impregnated at a very early stage; the male presumably lops in the gap between cyclopid and last-stage copepodid.

When the lobster moults, the *Nicothoë* are shed with the old shell and die, and reinfestation by ement of last-stage copepodids can only occur in significant numbers shortly after the moult, before gills become hard again. There is a seasonal rhythm in the release of cyclopid larvae by the adult les, there being two peaks, of which one coincides with the lobster's main moulting season (May-ust) and the other with a subsidiary moulting period of younger lobsters (November).

DEGREE OF INFESTATION AND EFFECT ON THE HOST

A sample of 40 lobsters (18 hard, 22 fairly soft) which died in transit from Bernera, Lewis, to Oban ugust 1956 was examined, and counts of *Nicothoë* made, and this was compared with a sample of bsters (36 hard, 13 fairly soft) from the same batch which arrived at Oban in good condition. The taken in transit was approximately thirty hours.

A graphical analysis of the observations on lobster length and *Nicothoë* count showed that although umber of parasites varied greatly between lobsters of the same length, there was a clear tendency urger lobsters to be more heavily infested than smaller ones. This was true in both living and dead ers. The relation between *Nicothoë* count and lobster length appeared to be non-linear, larger ers having disproportionately more *Nicothoë* in relation to length than smaller ones. The gill area able for settlement is approximately proportional to the square of the length, and is, therefore, derably greater in larger lobsters.

In addition, the variation in *Nicothoë* count increased with the mean level of infestation. This effe is shown in Table I, which was drawn up by grouping the forty observations on dead lobsters into fi

TABLE I

Relationship between Mean Level of Infestation and Standard Deviation (Dead lobsters)

Group	Range of carapace lengths (mm.)	Mean	Standard Deviation
1	7·4—8·1	1·75	3·88
2	8·2—9·0	2·25	2·05
3	9·4—9·8	9·62	10·68
4	10·0–10·7	35·25	55·00
5	10·8–12·7	85·12	77·27

groups of eight by carapace length. With these considerations in mind it was decided to use the logarith of the counts in further analysis. This has two desirable effects, in that it makes the relationship betwe *Nicothoë* count and lobster length linear or approximately so, and that it tends to reduce the depender of the standard deviation on mean count. The data corresponding to that given in Table I for t observations transformed according to the equation $y=\log_{10}(x+1)$, where x is the actual number *Nicothoë*, are shown in Table II.

TABLE II

Relationship between Mean and Standard Deviation (Transformed scale)

Group	Mean	Standard Deviation
1	0·21	0·410
2	0·43	0·309
3	0·65	0·520
4	0·97	0·851
5	1·58	0·742

The lobsters, in addition to being classified as dead and living, were also classified as hard a fairly soft. In assessing the significance of differences between the average counts for the lobsters in ea of the four classes it was necessary to allow for the fact that the average length of the lobsters var from class to class. This was done by carrying out an analysis of covariance on length. A furth complication taken into account was the fact that the numbers of lobsters in the four classes were unequ The final analysis, shown below, did not reveal any significant difference between the dead and liv or between the hard and fairly soft lobsters.

	d.f.	S. of S.	m.s.
Living *v* dead	1	0·9488	0·9488
Hard *v* soft .	1	0·0041	0·0041
Interaction .	1	0·3550	0·3550
Error . .	84	22·3083	0·3656

The average linear regression of transformed count on length is:

$$\log_{10}(x+1)=0{\cdot}3685\ l-2{\cdot}557$$

Fig. 1 Last four gills of left-hand side of lobster showing heavy infestation with *Nicothoë* (total infestation ca 1700). Mallaig, 19th July, 1955.

The average infestation rates at various lengths as obtained from this regression are given in Table III.

TABLE III

Estimated Average Infestation Rates

Carapace length cm ..	8·0	9·0	10·0	11·0	12·0
Average infestation ..	1·4	4·7	12·3	30·2	71·8

It appears that the fairly soft lobsters in this experiment had their full complements of *Nicothoë* and d presumably hardened beyond the stage at which further infestation was possible. It seems certain t, at least in this instance, mortality in transit was not due to weakness caused by *Nicothoë*.

AREA COMPARISONS

Samples of hard lobsters were obtained from the following areas during the period September, 55–June, 1956:

Burnmouth and Eyemouth (Berwickshire—east coast) .	5
Fraserburgh (Aberdeenshire—east coast) . .	10
Dunnet Head and Keiss (Caithness) . .	32
Orkney	40
Bernera (Lewis—west coast) . . .	56
Port Erin (Isle of Man)	11

e numbers refer to the numbers of lobsters examined.

Nicothoë was present in all the areas considered. In comparing infestation rates in different areas s necessary to eliminate differences ascribable to the length of the lobster, and this was done by means an analysis of covariance carried out on the logarithms of the *Nicothoë* counts, for the reasons given ove (p. 4). The mean levels, adjusted for length differences, on the transformed scale, and their ndard errors, are shown in Table IV. The means and their 95% confidence limits on the untransformed le are shown in Table V. All the means are calculated for lobsters of mean carapace length 10·1 cm.

TABLE IV

Mean levels of Infestation in Different Areas (1955–56)
Transformed data

Area	Adjusted Mean	Standard Error (d.f. = 145)
Burnmouth and Eyemouth .	1·29	0·238
Fraserburgh . .	1·27	0·163
Dunnet Head and Keiss . .	1·41	0·094
Orkney	0·88	0·087
Bernera	1·50	0·070
Port Erin . . .	0·83	0·156

TABLE V

Mean Levels of Infestation in Different Areas (1955-56)
Original scale

Area	Derived Mean	95% Limits
Burnmouth and Eyemouth .	38·2	13·0 ——— 111·9
Fraserburgh . . .	36·2	17·4 ——— 75·7
Dunnet Head and Keiss .	51·0	33·2 ——— 78·0
Orkney . . .	14·2	9·6 ——— 21·0
Bernera . . .	61·8	45·8 ——— 86·0
Port Erin . . .	14·7	7·2 ——— 29·7

Tests of significance, carried out on the transformed scale, showed that the mean counts for Port E and Orkney were both significantly less than those for Dunnet Head and Keiss and Bernera ($P < 0{\cdot}00$ These were the only significant differences to emerge.

YEAR TO YEAR VARIATION IN THE LEVEL OF INFESTATION

When the lobster moults, the *Nicothoë* are cast off with the hard outer covering of the gills (Mas 1959). The act of moulting thus provides a natural means of regulating the numbers of the parasi and may result in wide fluctuations in the level of infestation from year to year.

With the available data it was possible to study year-to-year variations for one area only, v Bernera. Fifty-six hard lobsters caught between September 1955 and June 1956, which had not moult in 1956, were compared with sixty-seven hard lobsters caught in 1956 after the main casting seas Of the latter, all the males and approximately half the females would have moulted in that seas Again differences ascribable to size of lobster had to be eliminated before comparing the average lev of infestation in the two periods, and again this was done by an analysis of covariance. This analy showed a real difference between the levels of infestation in the two periods ($P < 0{\cdot}01$), the mean le in the lobsters caught before the 1956 moulting season being 1·9 times greater than in those caught af it. The 95% limits for this ratio are 1·2 and 3·0.

ECONOMIC ASPECTS OF INFESTATION BY *NICOTHOË*

In June, 1955, as stated in the introduction to this paper, there was a high mortality among lobst in the ponds at Yerseke, Holland. Korringa (1957) noticed that the lobsters, some of which had b imported from Scotland, were heavily infested with *Nicothoë*, and that the dead and weak ones carr decidedly more on average than the healthy survivors, though the individual fluctuations were rat great. Korringa did not consider that death had been caused by *Nicothoë*, but that, at most, the lobst general resistance was reduced by heavy parasitisation. In the present study, a comparison of lobst arriving dead with those arriving alive at Oban from Bernera, Lewis, suggested that death in tra was not due to reduced viability caused by *Nicothoë*, as there was no significant difference as rega degree of infestation between the dead and living lobsters. This, however, does not rule out Korring suggestion that heavy infestation may be detrimental to the host. The heaviest infestations found w approximately 1700 and 1500 respectively on the gills of two lobsters landed at Mallaig (Fig. 1). I quite conceivable that such large infestations could harm the lobster, both by the amount of blo withdrawn, causing anaemia, and by reducing considerably the area of gill available for oxygen trans (see Fig. 1). Such heavy infestations are, however, exceptional. Of 119 Bernera lobsters with hard sh examined, 102 (85·7%) had 100 or fewer *Nicothoë*, 84 (70·6%) had 50 or fewer, 53 (44·5%) had 10 fewer, and 10 (8·4%) were completely free from the parasite. In such small numbers, *Nicothoë* proba has little or no effect on its host.

Direct transfer of adult *Nicothoe* from one lobster to another cannot occur (Mason, 1959), but si in summer, many *Nicothoë* on lobsters in the ponds were carrying advanced larvae (Korringa, 19 it was thought that a mass release of cyclopid larvae, possibly occasioned by increased temperature the water in the ponds in summer, may have caused a heavy infestation of the lobster gills with yo stages, and been responsible for the increase in lobster mortality. The risk of such an infestation wo be increased by the recirculation of the water, carrying *Nicothoë* larvae, over the lobsters (Korrin 1957). Korringa, however, did not find any young stages of *Nicothoë* on the gills of weak and dy lobsters.

Moreover, the present study has shown experimentally that there is no correlation between rise temperature and the release of cyclopid larvae, nor is the release of larvae occasioned by the death

host. All lobsters used in these experiments were stored in a large tank before use. In each experiment hard lobster was placed in a glass tank 20½ inches long by 11 inches wide by 16½ inches deep, which s filled to a depth of 9 inches with sea water. A perforated "Perspex" partition some 3 inches from one l separated an aerator and cooling coil, in the smaller chamber, from the lobster. The control tanks l no heater, but the experimental tanks also contained an electric heater and thermostat in the smaller mber. Each control tank was kept at a reasonably constant temperature, the same as that of the age tank, which varied in individual instances from 13·8 to 18°C. The experimental lobsters were jected to either gradual (over a period of several days) or sudden increases of temperature. The den increases were brought about in either of two ways, either (i) by placing the lobster directly into ter of a higher temperature than that of the storage tank or (ii) by raising the temperature of the k quickly (2-3 hours). The tanks were left for only 7-10 days, as the water became foul and had to changed after that time. A sample of bottom water was removed from each tank daily, by means of ipping tube, and the numbers of cyclopids present counted. Each sample consisted of five dips, one in h corner and one in the middle of the tank, and was approximately 45 cc. in volume. Thus, while samples do not give the total numbers of larvae released, they do give the proportions in which y were released in the various experimental tanks.

The experiments were divided into those in which the temperature rose by more than 3.5 but less n 8°C, and those in which it rose by between 8 and 12°C. It was not possible to tell beforehand ether or not a lobster carried *Nicothoë* with active larvae, but the lobsters were chosen at random to nimize this factor. In all, twenty-one experiments and twenty-one controls were carred out.

Statistical analysis of the numbers of larvae released in each individual experiment has shown that differences between the means are not significant, and suggests that rise of temperature does not se release of cyclopid larvae.

Observations on six lobsters which died in tanks in August and September, all of which were infested h *Nicothoë*, showed that the parasites remained attached to the lobsters' gills, and did not release lopids, despite the fact that many of them carried active larvae. One parasite remained alive fifty-five rs after the host's death, when the water was foul.

Furthermore, it has been shown (Mason, 1959) that, even if larvae were released in ponds, infestation obster gills can only occur shortly after moulting, before the gills harden again, and moulting occurs y exceptionally in the ponds, where all lobsters stored are hard.

The real cause of increased mortality among lobsters in ponds in summer has recently been shown be Gaffkaemia, a bacterial disease which prevents the lobster's blood from clotting, so that injury ls to bleeding to death (Roskam, 1957).

I am grateful to Mr. J. A. Pope and the statistical staff of the Marine Laboratory for carrying out analyses of data. The generous co-operation of Crofters' Supply Agency, Oban, and St. Clair Fisheries, urso, in providing material is gratefully acknowledged.

SUMMARY

Larger lobsters are disproportionately more heavily infested with *Nicothoë* than smaller ones. *othoë* was found in all the areas covered by the study, though the level of infestation varied from e to place, being, for example, heavier at Bernera, Lewis, than at Orkney. The cleaning of the gills moulting results in variations from year to year in the degree of infestation.

A comparison of lobsters arriving dead with those arriving alive at a merchant's premises suggested t *Nicothoë* was not the cause of death in transit. It was concluded that the usual level of infestation 0 or less per lobster) caused little or no harm to the host, though heavier infestations might reduce general resistance.

Mass release of cyclopid larvae is unlikely to be caused in lobster storage ponds by increase in perature or death of the lobsters, and in any case little or no infestation of the lobsters stored would ur as they are almost all hard.

REFERENCES

GURNEY, R. 1929. The larva of *Nicothoë astaci* and its systematic position. J. mar. biol. Ass. U.K., V. pp. 453-9.

KORRINGA, P. 1957. Risks involved in lobster storage. I.C.E.S., Shellfish Committee, C.M. 1957, pp. 1-3.

MASON, J. 1959. The biology of *Nicothoë astaci* Audouin and Milne Edwards. J. mar. biol. Ass. U.K., **38,** (In Press).

ROSKAM, R. Th. 1957. Gaffkaemia, a contagious disease, in *Homarus vulgaris*. I.C.E.S., Shellfish Committ C.M. 1957. pp. 1-4.

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